

## British **Geological Survey**

### NATURAL ENVIRONMENT RESEARCH COUNCIL

The EarthServer FP7 project is implementing web coverage services using the OGC WCS and WCPS standards for a range of earth science domains: cryospheric; atmospheric; oceanographic; planetary; and geological. BGS is providing the geological service (http://earthserver.bgs.ac.uk/). Geoscience has used remote sensed data from satellites and planes for some considerable time, but other areas of geosciences are less familiar with the use of coverage data. This is rapidly changing with the development of new sensor networks and the move from geological maps to geological spatial models. The BGS geology service is designed initially to address two coverage data use cases and three levels of data access restriction.

data are typically very large and commonly held offline, making it time-consuming for users to assess and then download data. The service is designed to allow the spatial selection, editing and display of Landsat and aerial photographic imagery, including band selection and contrast stretching. This enables users to rapidly view data, assess is usefulness for their purposes, and then enhance and download it if it is suitable. At present the service contains six band Landsat 7 (Blue, Green, Red, NIR 1, NIR 2, MIR) and three band false colour aerial photography (NIR, green, blue), totalling around 1Tk

nodels are being produced in place of traditional geological maps. Models make explicit spatial information implicit on maps and thus are seen as a better way of delivering Increasingly 3D spatial geosciences information to non-geoscientists. However web delivery of models, including the provision of suitable visualisation clients, has proved more challenging than delivering maps. The EarthServer geology service is delivering 35 surfaces as coverages, comprising the modelled superficial deposits of the Glasgow area. These can be viewed using a 3D web client developed in the EarthServer project by

As well as remote sensed imagery and 3D models, the geology service is also delivering DTM coverages which can be viewed in the 3D client in conjunction with both imagery and models. The service is accessible through a web GUI which allows the imagery to be viewed against a range of background maps and DTMs, and in the 3D client; spatial selection to be carried out graphically; the results of image enhancement to be displayed; and selected data to be downloaded. The GUI also provides access to the Glasgow model in the 3D client, as well as tutorial material In the final year of the project it is intended to increase the volume of data to 20Tb and enhance the WCPS processing, including depth and thickness querying of 3D models. We have also investigated the use of GeoSciML, developed to describe and interchange the information on geological maps, to describe model surface coverages. EarthServer is developing a combined WCPS and xQuery query language, and we will investigate applying this to the GeoSciML described surfaces to answer questions such as 'find all units with a predominant sand lithology within 25m of the surface'.

### The EarthServer Geology Service

EarthServer, an ongoing e-Infrastructure EU-FP7 project ending in August 2014, is developing capabilities for access to, and ad-hoc processing of, large Earth science data sets using Open Geospatial Consortium standard web service interfaces for coverage data. At project close it is intended that at least 200TB of data, in total, will be available online through a number of 'lighthouse' services, covering the Cryospheric, Atmospheric, Planetary science, Oceanographic, and Geological domains.

The Geological domain lighthouse service will be served by the British Geological Survey (BGS), and will include services freely available to the public (e.g through the site http://earthserver.bgs.ac.uk), services available to signed up users, such as those in the Accessing Subsurface Knowledge (ASK) consortia, and services available to internal users only, and will provide online access to approximately 20 TB of data. The BGS service will be built entirely using open source software. The principal software being the Rasdaman (http://rasdaman.org/) array database system deployed within PostgreSQL, with Petascope providing the web services interfaces, and served using Tomcat and Apache http servers, all running on a CentOS Linux platform.

### Previewing Remotely Sensed Data

Many geosciences organisations hold large volumes of remotely sensed data which is used for a wide range of purposes such as regional mapping and resource identification. The large volumes mean the data is typically held offline and requires loading and previewing prior to download. This can be a time-consuming process and there is a requirement to be able to rapidly access data for an area of interest, assess it for suitability for the particular project objective, and then download it. Previewing the data requires visualisation, possibly in conjunction with other relevant data sets, and the ability to carry out simple image enhancement.

For the EarthServer Geology Service we have loaded multi-band satellite data and high resolution aerial photography for the UK. The satellite data comprises the six optical reflectance bands of Landsat 7 ETM +. This data is available in the EarthServer Geology public service:

**Domain:** 60 overlapping tiles surrounding single path and row Landsat scenes with null bordering pixels, typically 9186 x 8294 28.5m pixels covering UK, some parts several times. Geo-referenced to British National Grid (EPSG:27700)

**Range:** {byte x 6} 6 optical reflectance bands, null {0,0,0,0,0,0}

**Size:** ~ 25Gb (6 bytes x 9186 x 8294 x 60) raw data size

The aerial photographic data comprises RGB true colour and CIR false colour imagery, and due to licensing restrictions is only available on the EarthServer Geology BGS internal service:

#### **RGB True colour imagery:**

**Domain:** 240096 tiles each 4000 x 4000 0.25m square pixels covering land area of British Isles. Geo-referenced to British National Grid (EPSG:27700)

Range: {byte, byte, byte} red, green blue

**Size:** ~10Tb (3 bytes x 4000 x 4000 x 240096) raw data size

CIR false colour infra-red bands displayed as RGB:

**Domain:** 208573 tiles each 2000 x 2000 0.5m square pixels covering land area of British Isles. Geo-referenced to British National Grid (EPSG:27700)

**Range:** {byte, byte, byte} false colour infra-red bands as red, green, blue

Size: ~2.3Tb (3 bytes x 2000 x 2000 x 208573) raw data size

We have also loaded the Ordnance Survey of Great Britain Open Data UK DTM to the EarthServer Geology public service:

**Domain:** 2D square grid cell – Georeference British National Grid (EPSG:27700)

#### **Range:** {float} (elevation metres)

**Size:**~1.4Gb

The EarthServer Geology service incorporates a service portal for accessing the remotely sensed data. The initial page is an Open Layers based map of the UK with a choice of topographic backgrounds and a choice of geological WMS service layers, allowing the user to zoom in and select an area of interest. The Landsat 7 satellite tracks can also be viewed.

The user is then able to select to view Landsat tiles, aerial photography or the OS DTM. If Landsat tiles are selected the user is shown those within the selected area and can select one previewing. The user can allocate any three of the six bands of the selected image to the RGB display channels, and the image can then be viewed by itself or compared with other data. The viewing option allows the user to render the image and then display its histogram and enhance the image if required by stretching individual bands. The selected image can also be compared with aerial photography, the OS DTM or another Landsat image for the same area. The last option allows images from different seasons to be compared, and overlain, with possibly different geological features being visible in each. The image can also be overlain on the DTM and visualised in 3D using the 3D web client developed in the EarthServer project by Fraunhofer. This allows the topographic height to be exaggerated interactively in conjunction with the satellite image to identify possible geological features.

If the aerial photo option is chosen then the same viewing options are available. There is no tile selection however, as the aerial photographs provide a single coverage of the UK, but it is necessary for the user to select a sufficiently small area. This is because the high resolution of the photos means that selecting a large area would result in excessive processing. The user can view the extent of aerial photo coverage to assist in selecting a suitable area.

#### Delivering and Visualising 3D Geological Models

There has been a move amongst Geological Survey Organisations from producing geological maps to producing geological 3D spatial models. Geological maps often prove difficult for those without geological training to use whereas geological models allow the complex geometry and inter-relationships of geological objects, that is implicit on geological maps, to be made explicit. However, while digital geological maps and their underlying data can be delivered over the web using Web Mapping Services (WMS) and Web Feature Services (WFS), the delivery of geological models has proved problematic, commonly requiring users to download specific viewing software.

The EarthServer project has investigated the use of Web Coverage Services (WCS) to deliver 3D Geological spatial models that can be viewed using standard web browsers. The model of the superficial deposits of the Glasgow area is delivered by the EarthServer Geology service as a set of thirty-five grid surfaces, with each geological unit being bounded by an upper and lower surface. At present the rasdaman software used in the EarthServer project doesn't handle TINs but it is expected a future release of the software will do and thus allow more complex surfaces to be delivered.

The 3D model can be viewed using a web client that has been developed in the EarthServer project by Fraunhofer. This displays each surface with a colour reflecting the geological unit it bounds and allows the model to be interactively viewed from different directions as well as zoomed into. A 'key' to the right of the display allows surfaces to be switched on or off or have their transparency adjusted. This enables the user to explore the sequence and the relationship between surfaces by turning off, or fading out, surfaces in order and thus 'unpeel' the stratigraphy. There is also a function for interactively exaggerating the vertical dimension, to emphasise small differences that may have geological significance. Together the functionality is designed to allow the non-expert user to investigate and gain an understanding of the model.

EarthServer: www.earthserver.eu Geology Service: http://earthserver.bgs.ac.uk

Describing Models with GeoSciML GeoSciML is a GML based international geosciences data interchange language which has been developed to describe, mainly, the information commonly shown on geological maps. In the EarthServer project we have used it to describe the Glasgow 3D model delivered by the geology service. The surfaces in the model are geological unit contacts bounding implicit geological units. It is the properties of the geological units, such as lithology and age, which are of most interest to users. The base surface of each unit has been described and the BoundaryRelationship class used to relate this to a description of the overlying GeologicUnit containing information on lithology and age.

Normally GeoSciML features are delivered by a WFS as members of a FeatureCollection, but in the context of a WCS the GeoSciML has been added to the coverage metadata as it is providing a description of the coverage (see example). One of the main objectives of doing this is to be able to query the model against both GeoSciML properties and coverage values to answer questions such as 'Find all Geologic Units composed mainly of sand within 30m of the surface'.

EarthServer project partner ATHENA has developed the query language xWCPS aimed at merging xQuery's capabilities for handling XML with WCPS's raster data processing capabilities. We have used xWCPS to create queries (see example) which interrogate the GeoSciML in the metadata of the model surfaces to select those having a proportion of a specified lithology greater than a specified amount. The model and DTM coverage values are then used to calculate depth (the model coverage values are heights above datum) and the calculated depths used to select those surfaces which have a coverage represents a geological Contact feature which is related to the overlying GeologicUnit. Note maximum depth less than a specified amount. Finally images of the depth of the selected coverages are returned for display. the GeoSciML has been compressed - the full GeologicUnit description is indicated as [167 lines].



# The EarthServer Geology Service: web coverage services for geoscience John Laxton<sup>1</sup>, Marcus Sen<sup>2</sup>, and James Passmore<sup>2</sup>

## <sup>1</sup>British Geological Survey, Edinburgh, UK; <sup>2</sup>British Geological Survey, Keyworth



The service portal for remotely sensed data initially shows a geological map of the UK over which, optionally, the Landsat 7 satellite tracks can be displayed.



The user can zoom in, change the type of geological map if required, and select an area of interest. The background topographic map changes automatically with zoom.



The top view of the Glasgow superficial deposits 3D model, equivalent to the geological map. The map key is to the right and the vertical exaggeration bar to the bottom left.



An oblique view of the Glasgow superficial deposits 3D model with some vertical exaggeration. The sequence of deposits filling the Clyde valley can be clearly seen.

The GeoSciML description of the surface (the lower surface of the Paisley Clay Member) goes in the coverage metadata
The surface is a geological Contact
<gmlcov:metadata></gmlcov:metadata>
<pre><gmlcov:extension></gmlcov:extension></pre>
<gsmlst:contact gml:id="PAIS-TOP"></gsmlst:contact>
<gml:description>PAISLEY CLAY MEMBER (BASE)</gml:description>
<gsml:observationmethod> [17 lines]</gsml:observationmethod>
<gsml:purpose>instance</gsml:purpose>
The occurrence describes the geometric representation of the contact - which is also the domain of the coverage
<gsml:occurrence> [43 lines]</gsml:occurrence>
The BoundaryRelationship describes the relationship between the contact and the GeologicUnit which it underlies. The GeologicUnit</td
implicit rather than explicit in the model)>
<gsml:relatedfeature></gsml:relatedfeature>
<gsmlst:boundaryrelationship gml:id="LOCAL_ID_1"></gsmlst:boundaryrelationship>
<gsml:relationship< td=""></gsml:relationship<>
<pre>xlink:href="http://dummy.resource.geosciml.org/classifier/cgi/featurerelation/underlies"/&gt;</pre>
<gsml:sourcerole nilreason="missing" xsi:nil="true"></gsml:sourcerole>
<gsml:targetrole nilreason="missing" xsi:nil="true"></gsml:targetrole>
This is the description of the GeologicUnit
<gsml:relatedfeature></gsml:relatedfeature>
<gsmlgu:geologicunit gml:id="LOCAL_ID_2"> [167 lines]</gsmlgu:geologicunit>
<gsml:classifier nilreason="missing" xsi:nil="true"></gsml:classifier>
<gsml:metadata gco:nilreason="missing" xsi:nil="true"></gsml:metadata>
<gsmlst:contactcharacter nilreason="missing" xsi:nil="true"></gsmlst:contactcharacter>
<gsmlst:contacttype< td=""></gsmlst:contacttype<>
<pre>xlink:href="http://resource.geosciml.org/classifier/cgi/contacttype/0014"</pre>
<pre>xlink:title="Stratigraphic Boundary"/&gt;</pre>
<gsmlst:orientation nilreason="missing" xsi:nil="true"></gsmlst:orientation>
<gsmlst:correlateswith nilreason="missing" xsi:nil="true"></gsmlst:correlateswith>
mlcov:RectifiedGridCoverage>
outline of the GeoSciML within the metadata of one of the Glasgow 3D model surface coverages. The

When an area is selected the user is given the choice of rendering Landsat 7 images, aerial photography or the DTM. If Landsat images are selected the user chooses the tile required, the assignment of bands to RGB, and the viewing options





An oblique view of the Glasgow superficial deposits 3D model with some overlying deposits turned off. The basal surface of the Gourock formation has its transparency adjusted so its relationship with the underlying deposits can be seen.

```
for $c in (os dtm)
for $t in /server[@endpoint =
'http://earthserver.bgs.ac.uk/petascope']/formal/lastimage/harvested/coverages/coverage
for $comp in $t/coveragedescription/*[local-name()='CoverageDescription']/*[local-
name()='metadata']//*[local-name()='GeologicUnit']//*[local-name()='composition']
let $u:= scale($t, {x:"CRS:1"(0:419), y:"CRS:1"(0:407)}, {})
let $d := trim ($c,{x:"http://www.opengis.net/def/crs/EPSG/0/27700"(254750:265250),
y:"http://www.opengis.net/def/crs/EPSG/0/27700"(659824.9:670024.9)})
let $e:= scale($d, {x:"CRS:1"(0:419), y:"CRS:1"(0:407)}, {})
let $q:=($e*(not($u=-340282346638528859811704183484516925440.0)))
let $h:=($u*($u=-340282346638528859811704183484516925440.0))
let $i:=($g+$h)
let $f := ($i-$u)
 where
$comp//*[local-name()='lithology']/@*[local-name()='title'] = 'Clay'
$comp//*[local-name()='proportion']//*[local-name()='lowerValue']>=50
and max($f)<50
return encode ((char) (($f-min($f))*255)/(max($f) - min($f)), "png")
```



The xWCPS query above selects those coverages which underlie GeologicUnits having a lithology comprising >=50% Clay. The depth of each coverage is calculated by subtracting the height of the surface from the DTM, accounting for the fact that GeologicUnits do not cover the full extent of the coverage area and where a GeologicUnit is absent the coverage value is set to null (-340282346638528859811704183484516925440.0). The depth of those coverages where the maximum depth is less than 50m are encoded for display (see example to the left).

Rendered bandstretched composite of aerial photos for the Tayvallich area of Scotland. NIR, Green and Blue bands are allocated to RGB respectively. The tight folding in the Dalradian strata can be clearly seen. The red rectangle indicates the extent of the full resolution image shown below.



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# EarthServer **Big Earth Data Analytics**

If the 'view' option is selected the image is rendered and displayed and the user has the options of displaying the histogram and stretching the individual bands.

The chosen image can be displayed in 3D on top of the DTM. The user can exaggerate the elevation, change the lighting, and rotate the image.



Full resolution aerial photographic image for the area outlined by the red rectangle above. The lower resolution images can be used to identify and select the area required before downloading full resolution imagery.

